

capture variations in relay asset interactions, Earth/Mars time phasing, and seasonal variations in holidays). This model is used to estimate the ops efficiency factor for each operations configuration.

The second model in a separate Excel spreadsheet is a scenario model, which uses the sol types to rack up the total number of “scenario sols” for that scenario (in other words, the ideal number of sols it would take to perform the scenario objectives). Then, the number of sols requiring ground in the loop is cal-

culated based on the soil types contained in the given scenario. Next, the scenario contains a description of what sequence of operations configurations is used, for how many days each, and this is used with the corresponding ops efficiency factors for each configuration to calculate the “ops duration” corresponding to that scenario. Finally, a margin is applied to determine the minimum surface lifetime required for that scenario.

Typically, this level of analysis has not been performed until much later in the

mission, and has not been able to influence mission design. Further, the notion of moving to sustainable operations during Prime Mission — and the effect that that move would have on surface mission productivity and mission objective choices — has not been encountered until the most recent rover missions (MSL and Mars 2018).

*This work was done by Sharon L. Layback of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48262*

## GPU Lossless Hyperspectral Data Compression System

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Hyperspectral imaging systems onboard aircraft or spacecraft can acquire large amounts of data, putting a strain on limited downlink and storage resources. Onboard data compression can mitigate this problem but may require a system capable of a high throughput. In order to achieve a high throughput with a software compressor, a graphics processing unit (GPU) implementation of a compressor was developed targeting the current state-of-the-art GPUs from NVIDIA®.

The implementation is based on the fast lossless (FL) compression algorithm reported in “Fast Lossless Compression

of Multispectral-Image Data” (NPO-42517), *NASA Tech Briefs*, Vol. 30, No. 8 (August 2006), page 26, which operates on hyperspectral data and achieves excellent compression performance while having low complexity. The FL compressor uses an adaptive filtering method and achieves state-of-the-art performance in both compression effectiveness and low complexity. The new Consultative Committee for Space Data Systems (CCSDS) Standard for Lossless Multispectral & Hyperspectral image compression (CCSDS 123) is based on the FL compressor. The software makes use of the highly-parallel processing capa-

bility of GPUs to achieve a throughput at least six times higher than that of a software implementation running on a single-core CPU. This implementation provides a practical real-time solution for compression of data from airborne hyperspectral instruments.

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*The software used in this innovation is available for commercial licensing. Please contact Dan Broderick at [Daniel.F.Broderick@jpl.nasa.gov](mailto:Daniel.F.Broderick@jpl.nasa.gov). Refer to NPO-48571.*

## Robust, Optimal Subsonic Airfoil Shapes

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A method has been developed to create an airfoil robust enough to operate satisfactorily in different environments. This method determines a robust, optimal, subsonic airfoil shape, beginning with an arbitrary initial airfoil shape, and imposes the necessary constraints on the design. Also, this method is flexible and extendible to a larger class of requirements and changes in constraints imposed.

In one embodiment, process steps include providing a specification of a desired pressure value at each of a sequence of selected locations on the surface of a turbine airfoil; providing an initial airfoil shape; providing a statement of at least one constraint to which a final airfoil shape must conform; using computational fluid dynamics (CFD) to estimate a pressure value at each of the

selected perimeter locations for the initial airfoil shape; using CFD to determine the pressure distribution for the airfoil shapes that are small perturbations to the initial airfoil shape; and using an estimation method, such as a neural network, a support vector machine, or a combination thereof, to construct a response surface that models the pressure distribution as a function of the airfoil shape using the CFD data. Other process steps include using an optimization algorithm to search the response surface for the airfoil shape having the required pressure distribution, and providing at least one of an alphanumeric description and a graphical description of the modified airfoil shape.

Constraints may be drawn from the following group, or may be one or more other suitable constraints: vortex shed-

ding strength from the trailing edge of the airfoil is no greater than a selected threshold value; a difference between any resonant frequency of the airfoil and the vortex shedding frequency is at least equal to a threshold frequency difference; mass of the airfoil is no larger than a threshold mass value; and pressure value at each of a sequence of selected locations along the surface of the airfoil differs from a corresponding reference pressure value by no more than a threshold pressure difference value.

*This work was done by Man Mohan Rai of Ames Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at 1-855-NASA-BIZ (1-855-6272-249). Refer to ARC-14586-2*